~~AUTONOMOUS~~ STEP UP SWITCHING ~~TRANSFORMER~~CONVERTER

This application is a U.S. National Stage application of PCT Application No. PCT/AT 2004/000270, filed July 26, 2004, which claims priority from Austrian Application No. A 1423/2003, filed on September 9, 2003.

FIELD OF THE INVENTION

The present invention pertains to an ~~autonomous~~ step up switching converter for converting an input DC-voltage into an output DC-voltage.

BACKGROUND OF THE INVENTION

A large number of switching converters have become known for the supply of electronic devices, wherein a distinction is made between flyback converters and forward converters; however, mixed types have also become known. Complicated solutions meet the greatest variety of requirements regarding performance, short circuit-proofness, noiselessness, etc.

There are cases, in which for the current supply of smaller devices, e.g., even the control circuit of a switching converter, an auxiliary current supply is needed, on which special electrical requirements are not placed, which, however, will not noticeably affect the costs of the actual device, e.g., of a switching converter. Autonomous flyback converters, in which the presence of a transformer with an additional auxiliary winding is, however, required, are often used in such cases. One of many examples of such a flyback converter can be taken from, for example, DE 30 07 566 A1.

US 5 227 964 relates to a switching power supply with a transformer. An AC voltage is converted by means of a rectifier to a DC voltage, the latter being switched by a switching transistor to a primary winding of the transformer and the corresponding AC voltage at the secondary winding being converted by means of a two way rectifier into an output DC-voltage. The voltage across a measurement resistor on the primary side is compared with a reference voltage and an amplifier supplies an overcurrent shut-off signal to the control circuit of the switching transistor in order to limit the output current.

BRIEF SUMMARY OF THE INVENTION

The present invention is the creation of an autonomous switching converter, i.e., of a switching converter that does not need its own control component, which can be constructed with as few components as possible in a cost favorable manner.

In one exemplary embodiment ~~an autonomous~~a step up switching converter, ~~in~~ which, according to the present invention, ~~an input voltage can be applied to a storage inductor by means of a first~~ is characterized by a first semiconductor switch arranged in series connection with a storage inductor and a sensor resistor, the control electrode of said first semiconductor switch being connected via a resistor to said input voltage, said resistor constituting the operating resistor of a second semiconductor switch, the voltage drop of ~~a~~ said sensor resistor ~~that is connected in series to the switch~~ is fed to ~~a~~ the control electrode of ~~a~~ the second semiconductor switch as an indicator of the current through ~~the inductor, the input voltage is connected to the control electrode of the first switch via a resistor, this control electrode can be grounded via the switching path of the second switch, wherein, after switching on the input voltage during a first conduction phase of a first duration of the first switch and an increase in current through the inductor, the second switch becomes conductive and breaks the contact of the first switch, whereupon the storage inductor then supplies energy into an output capacitor for a second duration via a rectifier diode, until the capacitor of a series RC element that connects the switching input of the second switch~~ said storage inductor, and that connection of said storage inductor connected to said first semiconductor switch being connected on the one hand via a rectifier diode to an output capacitor which carries the output voltage and on the other hand via a series RC element to the control input ~~voltage is charged, the contact~~ of the second semiconductor switch ~~is broken, and the first switch becomes conductive again~~.

A flyback converter according to the present invention can be constructed with two transistors and ~~an~~ one inductor as well as with a few resistors and two capacitors and there is no need for a transformer nor for a separate control unit. Therefore, such a flyback converter is preferably suitable for the supply of smaller devices, e.g., also for the supply of the control circuit of a larger switching converter.

~~If only one inductor is used, the rectifier diode may galvanically connect the output capacitor to the storage inductor.~~

~~It is also possible, on the other hand, for the storage inductor to be formed by the primary winding of a transformer, on the secondary winding of which are connected the rectifier diode and the output capacitor. A greater dimensioning range is obtained by means of the selection of the transmission ratio of the two inductors in this case, which concerns the input voltage and the output voltage.~~

~~For protecting the second transistor and for improving the switching behavior, it may be expedient if the capacitor of the RC element can be discharged via a drop resistor and a discharge diode with the first switch switched on, wherein the drop resistor (R_S) is considerably smaller than the resistor of the RC element. For the same reason, it is advantageous if the control input of the second switch is protected by means of a reverse pole protection diode.~~

With regard to a simple decoupling it may be advantageous if the voltage drop across the sensor resistor is fed to the control electrode of the second semiconductor switch via a resistor.

If functioning of the converter shall also be guaranteed ~~without~~ in the absence of a load resistor, it is recommended that in order to control the output voltage ~~be regulated at the output capacitor. Such a regulation may advantageously occur such that~~ the switching path of a third semiconductor switch, whose control input is connected to the output voltage via a Zener diode, lies in parallel to the switching path of the second semiconductor switch.

~~However, when using a transformer, it is advisable if the switching path of the second switch is bridged over by the collector-emitter path of the phototransistor of an optocoupler, whose sending diode is connected at the output voltage via a Zener diode.~~

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention together with other advantages is described in detail below on the basis of ~~two~~ an exemplary ~~embodiments~~embodiment, which ~~are~~ is illustrated in the drawing. In this drawing:

Figure 1 shows the circuit of a switching converter according to the present invention with only one storage inductor.~~, and~~

~~Figure 2 shows another embodiment of a switching converter according to the present invention, which uses a transformer.~~

DETAILED DESCRIPTION OF THE INVENTION

As Figure 1 shows, a ~~direct~~ DC input voltage U_E is grounded by means of a storage inductor L1, the collector-emitter path of a transistor T1 and a sensor resistor R2. A resistor R1 leads from the positive pole of the ~~direct~~ DC input voltage U_E to the base of the transistor T1 and to the collector of another transistor T2, whose emitter is grounded. The emitter of the first transistor T1 leads the voltage drop at R2 via a resistor R4 to the base of the second transistor T2, which is connected to the connecting point of the storage inductor L1 and of the collector of the transistor T1 via the series connection of a capacitor C1 and a resistor R5. This ~~connecting~~ connection point leads to an output capacitor C2 via a rectifier diode D1.

If, as shown on the very right in Figure 1, a load resistor RB is not connected to the circuit just described, care must be taken for the regulation of the output voltage U_A at the capacitor C2. For this, a third transistor T3 is provided, whose collector-emitter path lies in parallel to the collector-emitter path of the transistor T2, and whose base is connected to the output voltage U_A via a resistor R6 and a Zener diode D4.

The transistors T1, T2 and T3 are, quite generally, controlled semiconductor switches, wherein field effect transistors (FETs) are preferably used.

The circuit according to the present invention works as follows. The direct input voltage U_E of, for example, 15 V, which may not exceed the allowable gate source voltage when using an FET, is connected at the storage inductor L1 as well as at the resistor R1. The gate of the transistor T1 is charged via the resistor R1, and this transistor switches on, as a result of which the current in the storage inductor L1 increases linearly. The amount of this current is shown at the sensor resistor R2, i.e., the voltage drop lying at this resistor is an indicator of the current through the inductor, and this voltage drop is fed to the second transistor T2 via the resistor R4. If the second transistor T2 is an npn transistor, and the voltage dropping at the

resistor R2 is greater than the base-emitter voltage of this transistor, this transistor becomes conductive and it switches off the transistor T1.

In the sense of the step-up principle the inductor L1 now tries to maintain the current flow and leads the current via the diode D1 into the output capacitor C2. The transistor T2 is kept conductive and the transistor T1 remains blocked via the capacitor C1 and the current-limiting resistor R5. Only if the capacitor C1 is charged, the transistor T1 is again released and again charged via the resistor R1. This process is repeated until the desired output voltage is reached. The described regulator based on the transistor T3 and the Zener diode D4 then intervenes, i.e., if the output voltage is reached, the transistor T3 is switched on via the Zener diode D4 and the resistor R6 and thus the gate of the transistor T1 is short-circuited. T1 remains switched off until the desired output voltage is again no longer exceeded, and then the Zener diode D4 no longer conducts and the transistor T3 releases the first transistor T1 again.

Thus, oscillations are interrupted in this simple circuit, if the desired voltage is reached. Two time constants, namely that of the storage inductor L1 and of the sensor resistor R2, which determine the switch-on threshold of the second transistor T2 and the switch-on duration t1, whereas the time constants of the capacitor C1 and of the resistor R5 determine the switch-off duration, are decisive for the function.

~~The circuit shown in Figure 2 corresponds essentially to the circuit according to Figure 1, which can be immediately seen by means of a comparison. It differs as follows:~~

~~The storage inductor L1 is formed here by the primary winding of a transformer UET, wherein the voltage occurring on the secondary winding L2 is in turn rectified by means of the diode D1 and the output capacitor C2 and leads to the output voltage~~ $\cancel{U_A}$~~.~~

~~The output voltage~~ $\cancel{U_A}$ ~~is regulated in that the phototransistor of an optocoupler OKO, which is used for the galvanic separation from the secondary side, is provided instead of the third transistor in Figure 1. On the secondary side, the sending diode of the optocoupler is controlled via a resistor R6 and a Zener diode D4, wherein exactly the same function as described in Figure 1 regarding voltage regulation is obtained.~~

~~Furthermore, another protective circuit is shown in Figure 2, which consists especially of the series connection of a drop resistor Rs and a diode D2, which connects the end of the capacitor C1 turned away from the storage inductor L1 to the~~

~~base of the transistor T2. Furthermore, the base-emitter path of this transistor T2 is bridged over by another diode D3.~~

~~This protective circuit is used to not allow the transistor T2 to have a negative voltage in any state of operation and additionally to quickly discharge the capacitor C1 in the conductive phase of the first transistor T1. With the transistor T1 switched on, the capacitor C1 with the time constant C1 x R_s is discharged via the series-connected diodes D2 and D3, wherein it is required that R3 is larger than R5, so that a quick discharge occurs. With the transistor T1 switched off, the capacitor C1 is slowly charged via the resistor R5 with the time constant C1 x R5. The time constant must be so selected that enough time remains for the demagnetization of the storage inductor L1, so that same does not conduct any current when the transistor T1 is switched on again.~~

~~It is also possible to operate the storage inductor L1 in trapezoid operation, wherein the time constant C1 x R5 is then selected to be correspondingly lower. When switching on the transistor T1, the diode D3 prevents a negative voltage at the base of the transistor and serves as reverse pole protection.~~

Although the invention is illustrated and described herein with reference to a specific embodiment, the invention is not intended to be limited to the details shown. Rather, various modifications may be made in the details within the scope and range of equivalents of the claims and without departing from the invention.